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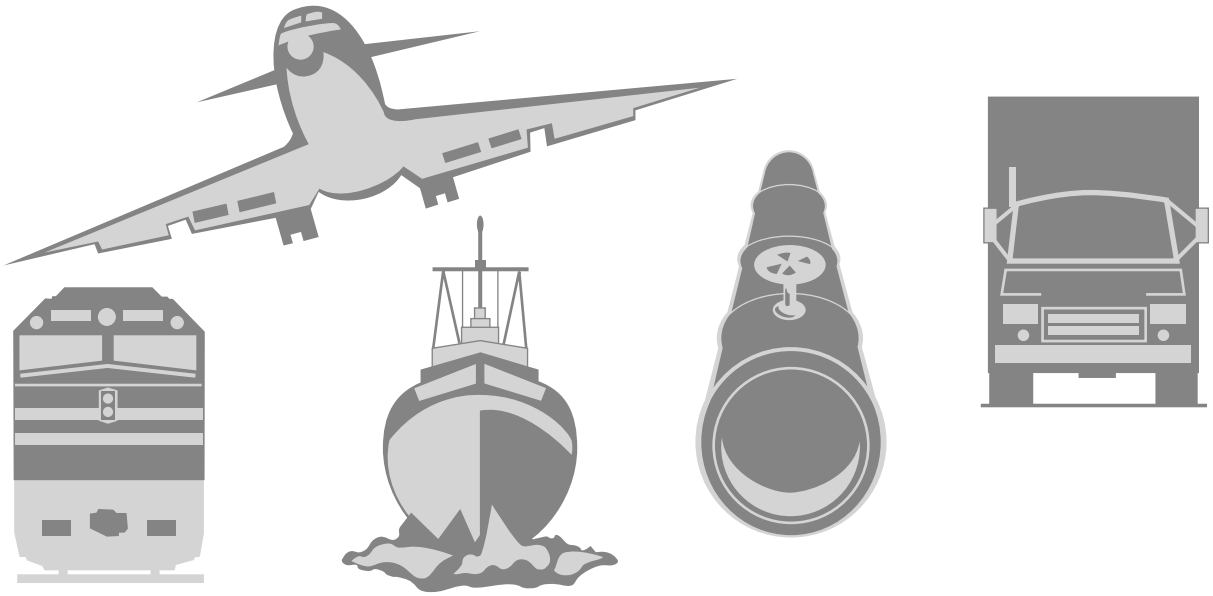
NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

SAFETY RECOMMENDATIONS

ADOPTED MAY 2002



National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: May 2, 2002

In reply refer to: M-02-1 through -4

Admiral James M. Loy
Commandant
U.S. Coast Guard
Washington, D.C. 20593-0001

On May 1, 1999, the amphibious passenger vehicle *Miss Majestic,* with an operator and 20 passengers on board, entered Lake Hamilton near Hot Springs, Arkansas, on a regular excursion tour. Shortly after entering the water, the vehicle listed to port and rapidly sank by the stern in 60 feet of water. One passenger escaped before the vehicle submerged but the remaining passengers and the operator were trapped by the vehicle's canopy roof and drawn under water. During the vehicle's descent to the bottom of the lake, 6 passengers and the operator were able to escape and, upon their reaching the water's surface, were rescued by pleasure boaters. The remaining 13 passengers, including 3 children, lost their lives. The vehicle damage was estimated at $100,000.[1]

The National Transportation Safety Board (Safety Board) determined that the probable cause of the uncontrolled flooding and sinking of the *Miss Majestic* was the failure of Land and Lakes Tours, Inc., to adequately repair and maintain the DUKW.[2] Contributing to the sinking was a flaw in the design of DUKWs converted to passenger service, that is, the lack of adequate reserve buoyancy that would have allowed the vehicle to remain afloat in a flooded condition. Contributing to the unsafe condition of the *Miss Majestic* was the lack of adequate oversight by the U.S. Coast Guard. Contributing to the high loss of life was a continuous canopy roof that entrapped passengers within the sinking vehicle. Based on its investigation of this accident, the Safety Board identified the following issues in the following safety areas: vehicle maintenance, Coast Guard inspections of the *Miss Majestic,* Coast Guard inspection guidance, reserve buoyancy, and survivability.

[1] For further information, read: National Transportation Safety Board, S*inking of the Amphibious Passenger Vehicle Miss Majestic, Lake Hamilton, Near Hot Springs, Arkansas, May 1, 1999*, Marine Accident Report NTSB/MAR-02/01 (Washington, DC: NTSB, 2002).

[2] A DUKW (pronounced "duck") is an amphibious landing vehicle that was designed to transport military personnel and supplies for the U.S. Army (Army) during World War II. After the war, many DUKWs were sold as surplus and, like the *Miss Majestic*, were converted to commercial excursion passenger vehicles.

The *Miss Majestic* was inspected and certificated by the Coast Guard as a small passenger vessel[3] meeting the requirements of 46 *Code of Federal Regulations* (CFR) Parts 175-185 (Subchapter T). Based on its length and its anticipated passenger load, the vehicle was required to have two bilge pumps: one with a pumping capacity of 10 gallons per minute (gpm) and a second with a pumping capacity of 5 gpm. The *Miss Majestic* was equipped with three electric pumps. In addition, the vehicle had a Higgins pump, which had been part of the original Army design but which was not required by Federal regulation. The Higgins pump had a maximum capacity of 250 gpm. The pump was chain-driven from the water propeller driveshaft and operated only when the driveshaft was engaged. While it operated, the pump discharged bilge water straight upward and overboard, creating a readily observable stream of water.

During postaccident interviews, the operator stated that, during the tour, she had not observed discharges from either the Higgins pump or the forward electric bilge pump.[4] The discharge pipes for the pumps had been to her left, and she had turned to her right to narrate the tour to the passengers, when the vehicle had begun to flood. She had also throttled the engine down while narrating.

When the *Miss Majestic* was salvaged from the water and examined, Safety Board investigators found that the hull was wasted through in some areas, but the holes were not large enough to allow the massive flooding experienced by the *Miss Majestic*. Detailed examination of the vehicle's hull and plugs did not reveal a structural failure through which massive flooding could have occurred.

The aft driveshaft that ran from the transfer case to the rear differential and drive wheels of the *Miss Majestic* had a housing for watertight protection. Each end of the aft shaft housing had an accordion rubber boot. The two rubber boots together with the shaft housing were to provide a watertight barrier where the driveshaft penetrated the hull. Postaccident examination revealed that the aft boot had separated from the housing at one end, creating a gap between the driveshaft and its housing that allowed water to freely enter the vehicle's hull. The DUKW had no bulkheads to contain the water within an interior division or other means of restricting the amount of water flooding the vehicle. The *Miss Majestic* trimmed by the stern with a small aft freeboard of 8 to 12 inches; thus, the floodwater accumulated at the stern. The DUKW had no built-in flotation or other reserve buoyancy to counter the flooding.

When Safety Board investigators fit the rubber boot back on the housing, they found that the clamp used to attach the boot to the housing was loose. They determined that, before the accident, a maintenance mechanic had replaced the aft boot because the original boot had a tear. His supervisor testified that, although replacing boots was not a complex task, it was possible to install a clamp improperly because working in the cramped conditions underneath the DUKW was difficult.

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[3] A vessel of less than 100 gross tons carrying more than six passengers for hire.

[4] The forward electric pump operated only when its float switch was activated by the presence of water. The aft electric pumps were activated by the operator turning on a toggle switch on the dashboard.

Postaccident testing and examination determined that the Higgins pump and one of the electric bilge pumps were inoperable. The Safety Board calculated that the rate of water inflow through the annular opening was at least 170 GPM. Although two electric pumps were operating, their combined pumping capacity was not enough to prevent the water buildup. At the rate of water ingress, the stern deck would have been awash within about 7 minutes. Once the stern slipped below the surface of the lake, water poured into the passenger compartment and swamped the vehicle, causing it to sink.

Revisions to Subchapter T required that existing vessels at least 26 feet long, which included the *Miss Majestic*, be equipped with high-level bilge alarms no later than March 11, 1999. Postaccident examination revealed the vehicle did not have a bilge alarm. Thus, the *Miss Majestic* had neither an active means of dewatering the vehicle nor a means of alerting the operator to the condition of the vehicle before it sank.

The Coast Guard had last inspected the *Miss Majestic* on February 23, 1999, a little more than 2 months before the accident. The inspector had reminded the owner's representative of the regulatory requirement. However, the Coast Guard inspector did not follow up to ensure the bilge alarm was installed. His report states that he examined the hull interior and exterior; however, he testified that he inspected the bottom of the vehicle by looking underneath it from the side. He did not get under the vehicle. The operation of the bilge pumps had not been tested with water. The Coast Guard policy required "operational checks" for bilge pumps. At the Safety Board's forum in December 1999, a representative from the Coast Guard's Inspection Division said that he interpreted this to mean that bilge pumps need not be tested with water. The inspector who last examined the *Miss Majestic* said that he believed that testing of pumps implied visually checking the pump and turning the operating switch on and off. Although the pumps passed inspections, the Safety Board's on-scene and laboratory analysis found that one of the Proline pumps was practically inoperative and the Higgins pump and its discharge piping showed evidence of longstanding poor maintenance.

The Safety Board determined that the last inspector's lack of attention to detail was not unique to him. None of the inspectors had noted any deficiencies regarding the hull plating of the *Miss Majestic* since 1994. Safety Board investigators found pinholes in the hull resulting from severe corrosion and a repair using a rubber patch to conceal a large wasted area of the hull. Hull corrosion is a slow process, especially in fresh water where the *Miss Majestic* operated. The hull, therefore, probably had been corroding for several years. Although the corrosion was easy to see, no inspection record indicates that the Coast Guard inspectors had either noted any difficulties with or required any repairs to be made to the corroded areas. The identification of such obvious areas of corrosion, improper patching, and degradation of hull integrity is rudimentary to Coast Guard inspections of all steel vehicles and vessels. In the case of the *Miss Majestic* and other DUKWs, the hull plating is so thin that it is susceptible to quicker holing through wastage and harder to repair. Based on its findings in the *Miss Majestic* accident, the Safety Board concluded that the Coast Guard's inspections of the vehicle were inadequate and cursory.

Before the *Miss Majestic* accident, the Coast Guard had not developed any nationwide guidance to field inspectors for inspecting DUKWs; the *Marine Safety*

Manual only addressed radiator cooling of DUKW engines. Although a few Coast Guard Marine Safety Offices (MSOs) had independently developed local policies for their inspectors, these policies did not address or emphasize several critical areas, such as inspecting the integrity of the hull, seals, clamps, or the need for operational testing of dewatering and bilge pumps. The local policies addressed different inspection issues that had arisen in each MSO. These policies were not disseminated to other MSOs.

Coast Guard inspection guidance for DUKWs would have been especially useful to the inspector who last examined the *Miss Majestic* because his experience with inspecting DUKWs was limited. He had received no special training in inspecting these vehicles. He had only inspected two DUKWs about 5 years earlier during his previous tour at MSO New Orleans. He told Safety Board investigators that he was unaware of any Coast Guard inspection policies or procedures for DUKWs. He stated that he had only talked to other inspectors to come up to speed on DUKWs. Neither the Officer-in-Charge, Marine Investigation nor the supervisor of inspectors at MSO Memphis had ever inspected a DUKW or was aware of any Coast Guard inspection procedures for DUKWs. The Safety Board concluded that the lack of Coast Guard guidance and training for the inspection of DUKWs contributed to the inadequate inspections of the *Miss Majestic*.

After its on-scene investigation of the *Miss Majestic* accident, the Safety Board researched the available accident history of amphibious passenger vehicles. Coast Guard data show that between March 6, 1991, and May 1, 1999, at least 18 amphibious passenger vehicles had been involved in accidents, and that six of the accidents had resulted in some degree of flooding. As a result, the Safety Board decided to hold a public forum in December 1999 on amphibious passenger vehicle safety to bring together the Coast Guard, the amphibious passenger vehicle industry, and technical experts to discuss amphibious passenger vehicle safety.

About the time that Safety Board opened its forum, the Coast Guard issued its final report on the sinking of the *Miss Majestic,* which concludes, in part:

> Had the *Miss Majestic* been fitted with watertight compartmentation or flotation materials, the vehicle would not have sunk or would have sunk so slowly that passengers would have had ample time to escape the vehicle.

The Safety Board's amphibious passenger vehicle forum produced important insights into the operation of such vehicles, safety issues unique to them, passenger accommodations design, and industry practices. One major outcome of the forum was the realization by participants that amphibious vehicles pose unique and unresolved safety risks to the public, but that the vehicles could be made safe by installing safety features that would prevent them from sinking when flooded. JMS, a naval architect company contracted by the Safety Board, had evaluated whether retrofitting DUKWs with foam and bulkheads would provide adequate reserve buoyancy to keep a DUKW afloat when it was flooded and fully loaded with passengers. JMS had determined that a DUKW carrying up to 28 passengers and an operator could be kept afloat when flooded if watertight bulkheads were added aft of the main engine at the firewall and aft of the rear wheel well and if buoyant foam were added between the fore and aft wheel wells along

the sides of the vehicle. At the forum, a JMS representative made a presentation on the flooding characteristics of DUKWs and stated that the estimated cost of installing the bulkheads and foam would be about $2,000 per DUKW plus about $10,000 for detailed engineering of the installations.

Based on its investigation of the *Miss Majestic* accident and the information presented at the forum about the vulnerability of amphibious passenger vehicles to flooding and sinking, on February 18, 2000, the Safety Board issued the following safety recommendation to 30 operators and refurbishers of amphibious passenger vehicles:

> M-00-5
>
> Without delay, alter your amphibious passenger vessels to provide reserve buoyancy through passive means, such as watertight compartmentalization, built-in flotation, or equivalent measures, so that they will remain afloat and upright in the event of flooding, even when carrying a full complement of passengers and crew.

In the Safety Board's opinion, a passive safety system is more reliable than active systems because it requires no deliberate action or operation to deploy and generally facilitates fail-safe performance of the vehicle. Consider the Higgins pump, which is powered by the DUKW's propeller shaft. Reliable operation of the pump cannot be assured because so many factors affect its proper performance, including, but not limited to, the operating condition of the pump, the operating condition of the main engine, and the vehicle operator's continuous depression of the gas pedal, which keeps the propeller shaft turning and the pump operating. Any shortcomings in maintenance of either the pump or the main engine, failure to identify a problem, use of poor repair techniques, or other causes can render the active system useless in an emergency.

In contrast, a passive safety system requires no deliberate action or operation to deploy and generally facilitates fail-safe performance of the vehicle. Examples of passive safety systems that can prevent a vehicle from sinking include compartmentalization with watertight bulkheads, installation of buoyant material inside the hull, and incorporation of buoyant sponsons exterior to the hull. Only the inherent reliability and fail-safe nature of a passive safety system can ensure the level of dependability essential to safeguarding the lives of passengers.

As of the date of the Safety Board's report on the *Miss Majestic* accident, only three owners of amphibious passenger vehicle companies have indicated that they were trying to install reserve buoyancy into their vehicles as requested by Safety Recommendation M-00-5. Other companies have expressed the opinion that installing watertight bulkheads and flotation foam would be difficult and would require detailed engineering. Some of the responses detailed other actions that companies were taking such as installing flow restrictor plates, additional bilge pumps, and additional high-water bilge alarms.

Despite the negative responses from amphibious passenger vehicle owners concerning the practicality of providing reserve buoyancy to DUKWs, they have not disputed the concept. Owner comments have focused on the detailed engineering required. Owners and manufacturers, however, have used and can use various methods to increase the survivability of amphibious vehicles in the event of flooding. It is clear, however, from the responses received from the industry, that with the exception of a few owners, the industry will not take voluntary action to address the need for adequate reserve buoyancy on amphibious passenger vehicles.

As a result, an unacceptable level of risk to passenger safety continues to exist on these vehicles. The Safety Board notes that the Coast Guard's report of the *Miss Majestic* sinking concluded, and the Coast Guard Commandant concurred, the following:

> DUKWs have features which make them inherently less safe than conventional commercial passenger vessels.

Because the industry has, by and large, refused to take voluntary action to address this risk, the Safety Board considers it imperative that a regulatory authority takes steps to ensure that all amphibious passenger vehicles will not sink in the event of an uncontrolled flooding event. The Safety Board, therefore, believes that the Coast Guard should require that amphibious passenger vehicle operators provide reserve buoyancy through passive means, such as watertight compartmentalization, built-in flotation, or equivalent measures, so that the vehicles will remain afloat and upright in the event of flooding, even when carrying a full complement of passengers and crew.

Following its investigation of the *Miss Majestic* accident and after participating at the Safety Board's forum, the Coast Guard met with representatives of the amphibious passenger vehicle industry to develop comprehensive guidelines containing best practices on the inspection and operation of these vehicles. The Coast Guard subsequently issued Navigation and Vessel Inspection Circular (NVIC) 1-01, *Inspection of Amphibious Passenger Carrying Vehicles*, to provide its inspectors and industry with necessary background information and guidance about DUKWs.

NVIC 1-01 contains 40 pages of information and guidance on such items as unique design features, inspection and certification, construction and arrangement, intact stability and seaworthiness, watertight integrity, lifesaving equipment and arrangements, and fire protection equipment. The NVIC contains a short history segment, numerous pictures, diagrams, and charts and provides inspectors with a list of 19 modifications that might have been made to a DUKW when it was converted to passenger service. The NVIC offers sample calculations for flooding, as well as expected scantlings. The circular is very well done as far as it goes; however, it is only an advisory document. Whether all amphibious passenger vehicle operators have incorporated the circular's advice into their vehicles or vehicle operations is not certain. Moreover, NVIC 1-01 does not adequately address important safety concerns, namely passenger egress and survivability.

For example, NVIC 1-01 recognizes canopies as an impediment to passenger egress. The circular does not address the safety implications of canopies over the

passenger seating areas or their negative impact on passenger survival in the event of sinking. During postaccident interviews with the survivors of the *Miss Majestic* accident, all but one person stated that the canopy was an impediment to escape. Of the seven fatalities found inside the vehicle, four were found trapped in the canopy. At least two survivors testified that they had to swim downward in order to escape from the canopy. If the vehicle had not had a canopy, the passengers would not have had a barrier to vertical escape. They would not have been trapped inside the vehicle, and fewer passengers might have drowned. The Safety Board found that on amphibious passenger vehicles such as the *Miss Majestic* that cannot remain afloat when flooded canopies are a major impediment to survival and can represent an unacceptable risk to safety. Therefore, a more realistic approach to ensure passenger safety would be to afford passengers a reasonable opportunity to escape by removing the canopy for waterborne operations or by installing a Coast Guard-approved canopy does not restrict either horizontal or vertical escape by passengers in the event of sinking.

In looking at the operation of DUKWs, the Safety Board recognizes that the removal of the canopy, by itself, is not adequate to ensure survivability of passengers in the event of sinking. Even though passengers would not be trapped inside a sinking vessel that did not have a canopy, they could still drown after they entered the water. As shown by the *Miss Majestic* accident, DUKWs without adequate reserve buoyancy will sink rapidly once water begins to flood into the hull, leaving little or no time for passengers to retrieve and don lifejackets or to assist children in donning lifejackets. The Safety Board, therefore, believes that where canopies have been removed on amphibious passenger vehicles for which there is not adequate reserve buoyancy, the Coast Guard should require that all passengers don lifejackets before the onset of waterborne operations.

Some of the owners of existing amphibious passenger vehicles have stated that the installation of adequate reserve buoyancy through passive means to existing vehicles is not practical. In the Safety Board's opinion, if providing existing amphibious passenger vehicles with sufficient reserve buoyancy through passive means to remain afloat and upright in the event of flooding is not practical, then alternative action that prevents passengers from being trapped inside the vehicle in the event of sinking should be taken. As noted earlier, the canopy should be removed before water operations so that passengers will float clear of the vehicle in the event of sinking, and passengers should be required to don lifejackets.

In addition, owners should be required to reduce through-hull penetrations and to install adequate dewatering capability to keep the vehicle afloat longer. The sinking of the *DUKW No. 1* on December 8, 2001,[5] clearly demonstrates what can happen to an amphibious passenger vehicle without sufficient reserve buoyancy if it experiences flooding and if it relies on the Higgins pump for dewatering. In that accident, *DUKW No. 1*, with 12 people on board, began flooding during a tour of Lake Union in Seattle, Washington. When the bilge alarm sounded repeatedly and the vehicle's Higgins pump

[5] Sinking of the *DUKW No.* 1, Lake Union, Seattle, Washington, December 8, 2001; Brief report in Appendix B of footnote 1.

began discharging water, the operator headed for shore. All passengers were transferred to a passing boat and taken ashore. The local harbor patrol, not knowing that an access plug was missing, attempted to tow the *DUKW No. 1* back across the lake. The harbor patrol asked the operator to turn off the engine and to leave the DUKW. Because the engine was not operating and, in turn, the Higgins pump was not operating to dewater the vehicle, the DUKW sank when water continued to flood the hull through the access plug opening. The Safety Board calculated that the flooding rate through the opening was about 330 GPM (a greater rate than a failed rubber boot), which exceeds the dewatering capacity of a Higgins pump. Therefore, the vessel might have sunk even if the Higgins pump had been operating.

The Safety Board investigated the sinking of the *DUKW No. 1* and determined that the vehicle owner had made the improvements suggested in the Coast Guard's NVIC, including installing a restrictor plate over the driveshaft hull penetration, double-clamped boot assemblies, bilge alarms, and hinge pin assembly. The vehicle also had a structurally sound hull and a working Higgins pump. Despite these attributes, *DUKW No. 1* sank because of a simple human error that occurred during routine maintenance.

In the case of the *DUKW No. 1*, company procedures required that, before a tour was conducted, both the mechanic and the operator sign the daily maintenance checklist attesting that they had checked 55 items, including engine fluid levels, tires, brakes, driveshaft rubber boots and clamps, and hull plugs. On the day of the accident, however, the operator was in a hurry to pick up waiting passengers and did not take the time to examine all the items listed on the safety checksheet. He told Safety Board investigators that he thought the maintenance access plug had been in place. A review of the daily maintenance checklist for *DUKW No. 1* shows not only that all items were checked, but also that both the operator and the mechanic had attested that the items had been checked. Therefore, a checksheet is no guarantee that necessary maintenance will be performed.

Following the *DUKW No. 1* accident, the owner of the vehicle decided to permanently seal the larger access plugs in all his DUKWs to reduce the likelihood of flooding. The change required some reengineering. Other amphibious passenger vehicle owners should be able to modify their vehicles to permanently close unnecessary access plugs, thus reducing the risk of flooding.

As discussed earlier in this letter, Higgins pumps are subject to multiple failure modes. If a Higgins pump malfunctions and the DUKW vehicle lacks sufficient reserve buoyancy to remain afloat, it could rapidly sink, risking serious injury or death to passengers. Further, the operation of the pump is contingent upon the operation of the engine. The Coast Guard NVIC 1-01 recognizes the need for an independent backup for the Higgins pump sufficient to provide enough dewatering capacity to offset flooding through the largest penetration of the vehicle's hull. In the Safety Board's opinion, dewatering capacity is essential to at least partially compensate for the lack of installed reserve buoyancy. While such capacity is not equivalent to built-in reserve buoyancy sufficient to keep the vehicle afloat in the event of unrestricted flooding, dewatering at least provides some measure of additional protection that may help to keep the vehicle afloat longer, giving passengers more time to escape before the vehicle sinks. Therefore,

until such time as reserve buoyancy requirements come into effect for amphibious passenger vehicles, a provision for dewatering capacity should be made mandatory.

Thus, the Safety Board believes that until such time that owners provide sufficient reserve buoyancy in their amphibious passenger vehicles so that they will remain upright and afloat in a fully flooded condition (by M-02-1), the Coast Guard should require the following: removal of canopies for waterborne operations or installation of a Coast Guard-approved canopy that does not restrict either horizontal or vertical escape by passengers in the event of sinking; reengineering of each amphibious vehicle to permanently close all unnecessary access plugs and to reduce all necessary through-hull penetrations to the minimum size necessary for operation; installation of independently powered electric bilge pumps that are capable of dewatering the craft at the volume of the largest remaining penetration to supplement either an operable Higgins pump or a dewatering pump of equivalent or greater capacity; installation of four independently powered bilge alarms; inspection of the vehicle in the water after each time a through-hull penetration has been removed or uncovered; verification of a vehicle's watertight condition in the water at the outset of each waterborne departure; and compliance with all remaining provisions of *Navigation and Vessel Inspection Circular 1-01*.

Following the *Miss Majestic* accident, the Safety Board investigated another amphibious passenger vehicle accident that resulted from inadequate maintenance. On September 18, 2000, the *Minnow*, a 21-foot-long Alvis Stalwart-type (Stalwart) amphibious sightseeing vehicle, with 2 crewmembers and 17 passengers on board, was proceeding through the Milwaukee, Wisconsin, harbor when the operator heard a "mechanical noise" and felt the vehicle "shudder." Shortly thereafter, the bilge alarm sounded. The operator turned back to shore; however, the vehicle's engine stopped when the engine flooded, and the operator had to radio for assistance. The marine police and Coast Guard personnel responded and safely transferred all of the *Minnow*'s passengers to their vessels. The *Minnow* then sank in 25 feet of water.[6]

During postaccident examination, the Safety Board Materials Laboratory in Washington, D.C. determined that the port propulsion unit had failed because its aft shaft bearing failed from inadequate lubrication. Severe corrosion on the shaft bearing retaining nut indicated that the integrity of the bearing and oil cavity had been compromised for a significant period before the accident, allowing water to enter the oil chamber, corrode the nut, and degrade the lubricating oil.

While investigating the *Minnow* accident, the Safety Board found that, as in the case with the principals in the *Miss Majestic* accident, the operators, refurbishers, and inspectors had an inadequate understanding of the risks posed by amphibious passenger vehicles. In reviewing the NVIC, the Safety Board found that it does not address the inspection issues of other types of amphibious passenger vehicles such as Stalwarts. Thus, guidance and background information relating to maintenance, inspection, and operation of Stalwarts is not readily available for use by owners, operators, refurbishers,

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[6] Sinking of the Alvis Stalwart M/V *Minnow* in Milwaukee Harbor on September 18, 2000; Brief report in Appendix B of footnote 1.

and inspectors. In the Safety Board's opinion, industry and Coast Guard inspectors need to become familiar with the general background of and unique safety issues for all types of amphibious vehicles, such as Stalwarts, to improve the maintenance, inspection, and operation of specialized amphibious vehicles. The Safety Board, therefore, believes that the Coast Guard should develop and promulgate guidance for all amphibious passenger vehicles similar in purpose to NVIC 1-01.

In summary, the National Transportation Safety Board makes the following safety recommendations to the U.S. Coast Guard:

> Require that amphibious passenger vehicle operators provide reserve buoyancy through passive means, such as watertight compartmentalization, built-in flotation, or equivalent measures, so that the vehicles will remain afloat and upright in the event of flooding, even when carrying a full complement of passengers and crew. (M-02-1).

> Until such time that owners provide sufficient reserve buoyancy in their amphibious passenger vehicles so that they will remain upright and afloat in a fully flooded condition (by M-02-1), require the following:

> (1) removal of canopies for waterborne operations or installation of a Coast Guard-approved canopy that does not restrict either horizontal or vertical escape by passengers in the event of sinking,

> (2) reengineering of each amphibious vehicle to permanently close all unnecessary access plugs and to reduce all necessary through-hull penetrations to the minimum size necessary for operation,

> (3) installation of independently powered electric bilge pumps that are capable of dewatering the craft at the volume of the largest remaining penetration to supplement either an operable Higgins pump or a dewatering pump of equivalent or greater capacity,

> (4) installation of four independently powered bilge alarms,

> (5) inspection of the vehicle in the water after each time a through-hull penetration has been removed or uncovered,

> (6) verification of a vehicle's watertight condition in the water at the outset of each waterborne departure, and

> (7) compliance with all remaining provisions of *Navigation and Vessel Inspection Circular1-01*. (M-02-2)

Where canopies have been removed on amphibious passenger vehicles for which there is no adequate reserve buoyancy, require that all passengers don lifejackets before the onset of waterborne operations. (M-02-3)

Develop and promulgate guidance for all amphibious passenger vehicles similar in purpose to the *Navigation and Vessel Inspection Circular* 1-01. (M-02-4)

As a result of this investigation, the Safety Board has issued three safety recommendations to the States of New York and Wisconsin. In your response to the recommendations in this letter, please refer to M-02-1 through -4. If you need additional information, you may call (202) 314-6607.

Chairman BLAKEY, Vice Chairman CARMODY and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations.

Original Signed

By: Marion C. Blakey
Chairman

National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: May 2, 2002

In reply refer to: M-02-1 through -3

Honorable George E. Pataki
Office of the Governor
State Capitol
Albany, New York 12224

The National Transportation Safety Board (Safety Board) is an independent Federal agency charged by Congress with investigating transportation accidents, determining their probable cause, and making recommendations to prevent similar accidents from occurring. We are providing the following information to urge your State to take action on the safety recommendations in this letter. The Safety Board is vitally interested in these recommendations because they are designed to prevent accidents and save lives.

The recommendations address the following safety issues: the adequacy of vehicle maintenance, the adequacy of Coast Guard inspections of the *Miss Majestic,* the adequacy of Coast Guard inspection guidance, the adequacy of reserve buoyancy, and the adequacy of survivability. The recommendations are derived from the Safety Board's investigation of the sinking of the amphibious passenger vehicle *Miss Majestic,* in Lake Hamilton, Arkansas, on May 1, 1999, and are consistent with the evidence we found and the analysis we performed.[1] As a result of this investigation, the Safety Board has issued the three safety recommendations to the Governors of the States of Wisconsin and New York and four safety recommendations to the U.S. Coast Guard. The Safety Board would appreciate a response from you within 90 days addressing actions you have taken or intend to take to implement our recommendations.

On May 1, 1999, the amphibious passenger vehicle *Miss Majestic,* with an operator and 20 passengers on board, entered Lake Hamilton near Hot Springs, Arkansas, on a regular excursion tour. About 7 minutes after entering the water, the vehicle listed to port and rapidly sank by the stern in 60 feet of water. One passenger escaped before the vehicle submerged but the remaining passengers and the operator were trapped by the vehicle's canopy roof and drawn under water. During the vehicle's descent to the bottom of the lake, 6 passengers and the operator were able to escape and, upon their reaching the water's surface, were rescued by pleasure boaters who happened to be in the area.

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The remaining 13 passengers, including 3 children, lost their lives. The vehicle damage was estimated at $100,000.

The Safety Board determined that the probable cause of the uncontrolled flooding and sinking of the *Miss Majestic* was the failure of Land and Lakes Tours, Inc., to adequately repair and maintain the DUKW.[2] Contributing to the sinking was a flaw in the design of DUKWs converted to passenger service, that is, the lack of adequate reserve buoyancy that would have allowed the vehicle to remain afloat in a flooded condition. Contributing to the unsafe condition of the *Miss Majestic* was the lack of adequate oversight by the Coast Guard. Contributing to the high loss of life was a continuous canopy roof that entrapped passengers within the sinking vehicle.

The *Miss Majestic* was inspected and certificated by the Coast Guard as a small passenger vessel[3] meeting the requirements of 46 *Code of Federal Regulations* (CFR) Parts 175-185 (Subchapter T). Based on its length and its anticipated passenger load, the vehicle was required to have two bilge pumps: one with a pumping capacity of 10 gallons per minutes (GPM) and a second with a pumping capacity of 5 GPM. The *Miss Majestic* was equipped with three electric pumps. In addition, the vehicle had a Higgins pump, which had been part of the original Army design but which was not required by Federal regulation. The Higgins pump had a maximum capacity of 250 GPM and, when it operated, discharged bilge water straight upward and overboard, creating a readily observable stream of water.

During postaccident interviews, the operator stated that, during the tour, she had not observed discharges from either the Higgins pump or the forward electric bilge pump.[4] The discharge pipes for the pumps had been to her left, and she had turned to her right to narrate the tour to the passengers, when the vehicle had begun to flood. She had also throttled the engine down while narrating.

When the *Miss Majestic* was salvaged from the water and examined, Safety Board investigators found that the hull was wasted through in some areas, but the holes were not large enough to allow the massive flooding experienced by the *Miss Majestic*. Detailed examination of the vehicle's hull and plugs did not reveal a structural failure through which massive flooding could have occurred.

The aft driveshaft that ran from the transfer case to the rear differential and drive wheels of the *Miss Majestic* had a housing for watertight protection. Each end of the aft shaft housing had an accordion rubber boot. The two rubber boots together with the shaft housing were to provide a watertight barrier where the drive axle penetrated the hull. Postaccident examination revealed that the aft boot had separated from the housing at one

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When Safety Board investigators fit the rubber boot back on the housing, they found that the clamp used to attach the boot to the housing was loose. They determined that, before the accident, a maintenance mechanic had replaced the aft boot because the original boot had a tear. His supervisor testified that, although replacing boots was not a complex task, it was possible to install a clamp improperly because working in the cramped conditions underneath the DUKW was difficult.

Postaccident testing and examination determined that the Higgins pump and one of the electric bilge pumps were inoperable. The Safety Board calculated that the rate of water inflow through the annular opening was at least 170 GPM. Although two electric pumps were operating, their combined pumping capacity was not enough to prevent the water buildup. At the rate of water ingress, the stern deck would have been awash within about 7 minutes. Once the stern slipped below the surface of the lake, water poured into the passenger compartment and swamped the vehicle, causing it to sink.

Revisions to Subchapter T required that existing vessels at least 26 feet long, which included the *Miss Majestic*, be equipped with high-level bilge alarms no later than March 11, 1999. Postaccident examination revealed the vehicle did not have a bilge alarm. Thus, the *Miss Majestic* had neither an active means of eliminating the bilge water nor a means of alerting the operator to the condition of the vehicle before it sank.

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The Safety Board's amphibious passenger vehicle forum produced important insights into the operation of such vehicles, safety issues unique to them, passenger accommodations design, and industry practices. One major outcome of the forum was the realization by participants that amphibious vehicles pose unique and unresolved safety risks to the public, but that the vehicles could be made safe by retroactively installing safety features that would prevent them from sinking when flooded. JMS, a naval architect company contracted by the Safety Board, had evaluated whether retrofitting DUKWs with foam and bulkheads would provide adequate reserve buoyancy to keep a DUKW afloat when it was flooded and fully loaded with passengers. JMS had determined that a DUKW carrying up to 28 passengers and an operator could be kept afloat when flooded if watertight bulkheads were added aft of the main engine at the firewall and aft of the rear wheel well and if buoyant foam were added between the fore and aft wheel wells along the sides of the vehicle. At the forum, a JMS representative made a presentation on the flooding characteristics of DUKWs and stated that the estimated cost of installing the bulkheads and foam would be about $2,000 per DUKW plus about $10,000 for detailed engineering of the installations.

Based on its investigation of the *Miss Majestic* accident and the information presented at the forum about the vulnerability of amphibious passenger vehicles to

flooding and sinking, on February 18, 2000, the Safety Board issued the following safety recommendation to 30 operators and refurbishers of amphibious passenger vehicles:

> M-00-5
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> Without delay, alter your amphibious passenger vessels to provide reserve buoyancy through passive means, such as watertight compartmentalization, built-in flotation, or equivalent measures, so that they will remain afloat and upright in the event of flooding, even when carrying a full complement of passengers and crew.

In the Safety Board's opinion, a passive safety system is more reliable than active systems because it requires no deliberate action or operation to deploy and generally facilitates fail-safe performance of the vehicle. Consider the Higgins pump, which is powered by the DUKW's propeller shaft. Reliable operation of the pump cannot be assured because so many factors affect its proper performance, including, but not limited to, the operating condition of the pump, the operating condition of the main engine, and the vehicle operator's continuous depression of the gas pedal, which keeps the propeller shaft turning and the pump operating. Any shortcomings in maintenance of either the pump or the main engine, failure to identify a problem, use of poor repair techniques, or other causes can render the active system useless in an emergency.

In contrast, a passive safety system requires no deliberate action or operation to deploy and generally facilitates fail-safe performance of the vehicle. Examples of passive safety systems that can prevent a vehicle from sinking include compartmentalization with watertight bulkheads, installation of buoyant material inside the hull, and incorporation of buoyant sponsons exterior to the hull. Only the inherent reliability and fail-safe nature of a passive safety system can ensure the level of dependability essential to safeguarding the lives of passengers. The Safety Board, therefore, believes that regulatory authorities should require that amphibious passenger vehicle operators provide reserve buoyancy through passive means, such as watertight compartmentalization, built-in flotation, or equivalent measures, so that the vehicles will remain afloat and upright in the event of flooding, even when carrying a full complement of passengers and crew.

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NVIC 1-01 contains 40 pages of information and guidance on such items as unique design features, inspection and certification, construction and arrangement, intact stability and seaworthiness, watertight integrity, lifesaving equipment and arrangements, and fire protection equipment. The NVIC contains a short history segment, numerous pictures, diagrams, and charts and provides inspectors with a list of 19 modifications that

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For example, NVIC 1-01 recognizes canopies as an impediment to passenger egress. The circular does not address the safety implications of canopies over the passenger seating areas or their negative impact on passenger survival in the event of sinking. During postaccident interviews with the survivors of the *Miss Majestic* accident, all but one person stated that the canopy was an impediment to escape. Of the seven fatalities found inside the vehicle, four were found trapped in the canopy. At least two survivors testified that they had to swim downward in order to escape from the canopy. If the vehicle had not had a canopy, the passengers would not have had a barrier to vertical escape. They would not have been trapped inside the vehicle, and fewer passengers might have drowned. Therefore, a more approach to ensure passenger safety would be to afford passengers a reasonable opportunity to escape by removing the canopy for waterborne operations or by installing a Coast Guard-approved canopy does not restrict either horizontal or vertical escape by passengers in the event of sinking.

In looking at the operation of DUKWs, the Safety Board recognizes that the removal of the canopy, by itself, is not adequate to ensure survivability of passengers in the event of sinking. Even though passengers would not be trapped inside a sinking vessel that did not have a canopy, they could still drown after they entered the water. As shown by the *Miss Majestic* accident, DUKWs without adequate reserve buoyancy will sink rapidly once water begins to flood into the hull, leaving little or no time for passengers to retrieve and don lifejackets or to assist children in donning lifejackets. The Safety Board, therefore, believes that regulatory authorities should require, where canopies have been removed on amphibious passenger vehicles for which there is not adequate reserve buoyancy, all passengers to don lifejackets before the onset of waterborne operations.

As of the date of the Safety Board's report on the *Miss Majestic* accident, only three owners of amphibious passenger vehicle companies have indicated that they were trying to install reserve buoyancy into their vehicles as requested by Safety Recommendation M-00-5. Other companies have expressed the opinion that installing watertight bulkheads and flotation foam would be difficult and would require detailed engineering. Some of the responses detailed other actions that companies were taking such as installing flow restrictor plates, additional bilge pumps, and additional high-water bilge alarms.

Some of the owners of existing amphibious passenger vehicles have stated that the installation of adequate reserve buoyancy through passive means to existing vehicles is not practical. In the Safety Board's opinion, if providing existing amphibious passenger vehicles with sufficient reserve buoyancy through passive means to remain afloat and upright in the event of flooding is not practical, then alternative action that prevents

passengers from being trapped inside the vehicle in the event of sinking should be taken. As noted earlier, the canopy should be removed before water operations so that passengers will float clear of the vehicle in the event of sinking, and passengers should be required to don lifejackets.

In addition, owners should be required to reduce through-hull penetrations and to install adequate dewatering capability to keep the vehicle afloat longer. The sinking of the *DUKW No. 1* on December 8, 2001,[5] clearly demonstrates what can happen to an amphibious passenger vehicle without sufficient reserve buoyancy if it experiences flooding and if it relies on the Higgins pump for dewatering. In that accident, *DUKW No. 1*, with 12 people on board, began flooding during a tour of Lake Union in Seattle, Washington. When the bilge alarm sounded repeatedly and the vehicle's Higgins pump began discharging water, the operator headed for shore. All passengers were transferred to a passing boat and taken ashore. The local harbor patrol, not knowing that an access plug was missing, attempted to tow the *DUKW No. 1* back across the lake. The harbor patrol asked the operator to turn off the engine and to leave the DUKW. Because the engine was not operating and, in turn, the Higgins pump was not operating to dewater the vehicle, the DUKW sank when water continued to flood the hull through the access plug opening. The Safety Board calculated that the flooding rate through the opening was about 330 GPM (a greater rate than a failed rubber boot), which exceeds the dewatering capacity of a Higgins pump. Therefore, the vessel might have sunk even if the Higgins pump were operating.

The Safety Board investigated the sinking of the *DUKW No. 1* and determined that the vehicle owner had made improvements suggested in the Coast Guard's NVIC, including installing a restrictor plate over the driveshaft hull penetration, double-clamped boot assemblies, bilge alarms, and hinge pin assembly. The vehicle also had a structurally sound hull and a working Higgins pump. Despite these attributes, the *DUKW No. 1* sank because of a simple human error that occurred during routine maintenance. For a DUKW hull to have watertight integrity, perfect maintenance and operation is essential.

In the case of the *DUKW No. 1*, company procedures required that, before a tour was conducted, both the mechanic and the operator sign the daily maintenance checklist attesting that they had checked 55 items, including engine fluid levels, tires, brakes, driveshaft rubber boots and clamps, and hull plugs. On the day of the accident, however, the operator was in a hurry to pick up waiting passengers and did not take the time to examine all the items listed on the safety checksheet. He told Safety Board investigators that he thought the maintenance access plug had been in place. A review of the daily maintenance checklist for *DUKW No. 1* shows not only that all items were checked, but also that both the operator and the mechanic had attested that the items had been checked. Therefore, a checksheet is no guarantee that necessary maintenance will be performed.

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[5] Sinking of the *DUKW No.* 1, Lake Union, Seattle, Washington, December 8, 2001; Brief report in Appendix B of footnote 1.

Following the *DUKW No. 1* accident, the owner of the vehicle decided to seal the larger access plugs in all his DUKWs to reduce the likelihood of flooding. The change required some reengineering. Instead of using the forwardmost access plug to access the engine oil sump and filter, the plug was sealed and a portable pump is used to drain the sump. The oil filter was relocated so that it is accessible through the vehicle's hood. Other amphibious passenger vehicle owners should be able to modify their vehicles in a similar manner, thus eliminating a serious risk to passenger safety.

As discussed earlier in this letter, Higgins pumps are subject to multiple failure modes. If a Higgins pump malfunctions and the DUKW vehicle lacks sufficient reserve buoyancy to remain afloat, it could rapidly sink, risking serious injury or death to passengers. Further, the operation of the pump is contingent upon the operation of the engine. The Coast Guard NVIC 1-01 recognizes the need for an independent backup for the Higgins pump sufficient to provide enough dewatering capacity to offset flooding through the largest penetration of the vehicle's hull. In the Safety Board's opinion, dewatering capacity is essential to at least partially compensate for the lack of installed reserve buoyancy. While such capacity is not equivalent to built-in reserve buoyancy sufficient to keep the vehicle afloat in the event of unrestricted flooding, dewatering at least provides some measure of additional protection that may help to keep the vehicle afloat longer, giving passengers more time to escape before the vehicle sinks. Therefore, until such time as reserve buoyancy requirements come into effect for amphibious passenger vehicles, a provision for dewatering capacity should be made mandatory.

Thus, in the Safety Board's opinion, until such time that owners provide sufficient reserve buoyancy in their amphibious passenger vehicles so that they will remain upright and afloat in a fully flooded condition (by M-02-1), regulatory authorities should require equipment and procedural modifications to maximize safety during waterborne operations.

In summary, the National Transportation Safety Board makes the following safety recommendations to the State of New York:

> Require that amphibious passenger vehicle operators provide reserve buoyancy through passive means, such as watertight compartmentalization, built-in flotation, or equivalent measures, so that the vehicles will remain afloat and upright in the event of flooding, even when carrying a full complement of passengers and crew. (M-02-1).
>
> Until such time that owners provide sufficient reserve buoyancy in their amphibious passenger vehicles so that they will remain upright and afloat in a fully flooded condition (by M-02-1), require the following:
>
> (1) removal of canopies for waterborne operations or installation of a Coast Guard-approved canopy that does not restrict either horizontal or vertical escape by passengers in the event of sinking,
>
> (2) reengineering of each amphibious vehicle to permanently close all

unnecessary access plugs and to reduce all necessary through-hull penetrations to the minimum size necessary for operation,

(3) installation of independently powered electric bilge pumps that are capable of dewatering the craft at the volume of the largest remaining penetration to supplement either an operable Higgins pump or a dewatering pump of equivalent or greater capacity,

(4) installation of four independently powered bilge alarms,

(5) inspection of the vehicle in water after each time a through-hull penetration has been removed or uncovered,

(6) verification of a vehicle's watertight condition in the water at the outset of each waterborne departure, and

(7) compliance with all remaining provisions of *Navigation and Vessel Inspection Circular1-01*. (M-02-2)

Where canopies have been removed on amphibious passenger vehicles for which there is no adequate reserve buoyancy, require that all passengers don lifejackets before the onset of waterborne operations. (M-02-3)

In your response to the recommendations in this letter, please refer to M-02-1 through -3. If you need additional information, you may call (202) 314-6607.

Chairman BLAKEY, Vice Chairman CARMODY and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations.

Original Signed

By: Marion C. Blakey
Chairman

National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: May 2, 2002

In reply refer to: M-02-1 through -3

Honorable Scott McCallum
Office of the Governor
115 East State Capitol
Madison, Wisconsin 53702

The National Transportation Safety Board (Safety Board) is an independent Federal agency charged by Congress with investigating transportation accidents, determining their probable cause, and making recommendations to prevent similar accidents from occurring. We are providing the following information to urge your State to take action on the safety recommendations in this letter. The Safety Board is vitally interested in these recommendations because they are designed to prevent accidents and save lives.

The recommendations address the following safety issues: the adequacy of vehicle maintenance, the adequacy of Coast Guard inspections of the *Miss Majestic,* the adequacy of Coast Guard inspection guidance, the adequacy of reserve buoyancy, and the adequacy of survivability. The recommendations are derived from the Safety Board's investigation of the sinking of the amphibious passenger vehicle *Miss Majestic,* in Lake Hamilton, Arkansas, on May 1, 1999, and are consistent with the evidence we found and the analysis we performed.[1] As a result of this investigation, the Safety Board has issued the three safety recommendations to the Governors of the States of Wisconsin and New York and four safety recommendations to the U.S. Coast Guard. The Safety Board would appreciate a response from you within 90 days addressing actions you have taken or intend to take to implement our recommendations.

On May 1, 1999, the amphibious passenger vehicle *Miss Majestic,* with an operator and 20 passengers on board, entered Lake Hamilton near Hot Springs, Arkansas, on a regular excursion tour. About 7 minutes after entering the water, the vehicle listed to port and rapidly sank by the stern in 60 feet of water. One passenger escaped before the vehicle submerged but the remaining passengers and the operator were trapped by the vehicle's canopy roof and drawn under water. During the vehicle's descent to the bottom of the lake, 6 passengers and the operator were able to escape and, upon their reaching the water's surface, were rescued by pleasure boaters who happened to be in the area.

[1] For further information, read: National Transportation Safety Board, S*inking of the Amphibious Passenger Vehicle Miss Majestic, Lake Hamilton, Near Hot Springs, Arkansas, May 1, 1999*, Marine Accident Report NTSB/MAR-02/01 (Washington, DC: NTSB, 2001).

The remaining 13 passengers, including 3 children, lost their lives. The vehicle damage was estimated at $100,000.

The Safety Board determined that the probable cause of the uncontrolled flooding and sinking of the *Miss Majestic* was the failure of Land and Lakes Tours, Inc., to adequately repair and maintain the DUKW.[2] Contributing to the sinking was a flaw in the design of DUKWs converted to passenger service, that is, the lack of adequate reserve buoyancy that would have allowed the vehicle to remain afloat in a flooded condition. Contributing to the unsafe condition of the *Miss Majestic* was the lack of adequate oversight by the Coast Guard. Contributing to the high loss of life was a continuous canopy roof that entrapped passengers within the sinking vehicle.

The *Miss Majestic* was inspected and certificated by the Coast Guard as a small passenger vessel[3] meeting the requirements of 46 *Code of Federal Regulations* (CFR) Parts 175-185 (Subchapter T). Based on its length and its anticipated passenger load, the vehicle was required to have two bilge pumps: one with a pumping capacity of 10 gallons per minutes (GPM) and a second with a pumping capacity of 5 GPM. The *Miss Majestic* was equipped with three electric pumps. In addition, the vehicle had a Higgins pump, which had been part of the original Army design but which was not required by Federal regulation. The Higgins pump had a maximum capacity of 250 GPM and, when it operated, discharged water straight upward and overboard, creating a readily observable stream of water.

During postaccident interviews, the operator stated that, during the tour, she had not observed discharges from either the Higgins pump or the forward electric bilge pump.[4] The discharge pipes for the pumps had been to her left, and she had turned to her right to narrate the tour to the passengers, when the vehicle had begun to flood. She had also throttled the engine down while narrating.

When the *Miss Majestic* was salvaged from the water and examined, Safety Board investigators found that the hull was wasted through in some areas, but the holes were not large enough to allow the massive flooding experienced by the *Miss Majestic*. Detailed examination of the vehicle's hull and plugs did not reveal a structural failure through which massive flooding could have occurred.

The aft driveshaft that ran from the transfer case to the rear differential and drive wheels of the *Miss Majestic* had a housing for watertight protection. Each end of the aft shaft housing had an accordion rubber boot. The two rubber boots together with the shaft housing were to provide a watertight barrier where the drive axle penetrated the hull. Postaccident examination revealed that the aft boot had separated from the housing at one

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might have been made to a DUKW when it was converted to passenger service. The NVIC offers sample calculations for flooding, as well as expected scantlings. The circular is very well done as far as it goes; however, it is only an advisory document. Whether all amphibious passenger vehicle operators have incorporated the circular's advice into their vehicles or vehicle operations is not certain. Moreover, NVIC 1-01 does not adequately address important safety concerns, namely passenger egress and survivability.

For example, NVIC 1-01 recognizes canopies as an impediment to passenger egress. The circular does not address the safety implications of canopies over the passenger seating areas or their negative impact on passenger survival in the event of sinking. During postaccident interviews with the survivors of the *Miss Majestic* accident, all but one person stated that the canopy was an impediment to escape. Of the seven fatalities found inside the vehicle, four were found trapped in the canopy. At least two survivors testified that they had to swim downward in order to escape from the canopy. If the vehicle had not had a canopy, the passengers would not have had a barrier to vertical escape. They would not have been trapped inside the vehicle, and fewer passengers might have been drowned. Therefore, a more realistic approach to ensure passenger safety would be to afford passengers a reasonable opportunity to escape by removing the canopy for waterborne operations or by installing a Coast Guard-approved canopy does not restrict either horizontal or vertical escape by passengers in the event of sinking.

In looking at the operation of DUKWs, the Safety Board recognizes that the removal of the canopy, by itself, is not adequate to ensure survivability of passengers in the event of sinking. Even though passengers would not be trapped inside a sinking vessel that did not have a canopy, they could still drown after they entered the water. As shown by the *Miss Majestic* accident, DUKWs without adequate reserve buoyancy will sink rapidly once water begins to flood into the hull, leaving little or no time for passengers to retrieve and don lifejackets or to assist children in donning lifejackets. The Safety Board, therefore, believes that regulatory authorities should require, where canopies have been removed on amphibious passenger vehicles for which there is not adequate reserve buoyancy, all passengers to don lifejackets before the onset of waterborne operations.

As of the date of the Safety Board's report on the *Miss Majestic* accident, only three owners of amphibious passenger vehicle companies have indicated that they were trying to install reserve buoyancy into their vehicles as requested by Safety Recommendation M-00-5. Other companies have expressed the opinion that installing watertight bulkheads and flotation foam would be difficult and would require detailed engineering. Some of the responses detailed other actions that companies were taking such as installing flow restrictor plates, additional bilge pumps, and additional high-water bilge alarms.

Some of the owners of existing amphibious passenger vehicles have stated that the installation of adequate reserve buoyancy through passive means to existing vehicles is not practical. In the Safety Board's opinion, if providing existing amphibious passenger vehicles with sufficient reserve buoyancy through passive means to remain afloat and upright in the event of flooding is not practical, then alternative action that prevents

passengers from being trapped inside the vehicle in the event of sinking should be taken. As noted earlier, the canopy should be removed before water operations so that passengers will float clear of the vehicle in the event of sinking, and passengers should be required to don lifejackets.

In addition, owners should be required to reduce through-hull penetrations and to install adequate dewatering capability to keep the vehicle afloat longer. The sinking of the *DUKW No. 1* on December 8, 2001,[5] clearly demonstrates what can happen to an amphibious passenger vehicle without sufficient reserve buoyancy if it experiences flooding and if it relies on the Higgins pump for dewatering. In that accident, *DUKW No. 1*, with 12 people on board, began flooding during a tour of Lake Union in Seattle, Washington. When the bilge alarm sounded repeatedly and the vehicle's Higgins pump began discharging water, the operator headed for shore. All passengers were transferred to a passing boat and taken ashore. The local harbor patrol, not knowing that an access plug was missing, attempted to tow the *DUKW No. 1* back across the lake. The harbor patrol asked the operator to turn off the engine and to leave the DUKW. Because the engine was not operating and, in turn, the Higgins pump was not operating to dewater the vehicle, the DUKW sank when water continued to flood the hull through the access plug opening. The Safety Board calculated that the flooding rate through the opening was about 330 GPM (a greater rate than a failed rubber boot), which exceeds the dewatering capacity of a Higgins pump. Therefore, the vessel might have sunk even if the Higgins pump were operating.

The Safety Board investigated the sinking of the *DUKW No. 1* and determined that the vehicle owner had made improvements suggested in the Coast Guard's NVIC, including installing a restrictor plate over the driveshaft hull penetration, double-clamped boot assemblies, bilge alarms, and hinge pin assembly. The vehicle also had a structurally sound hull and a working Higgins pump. Despite these attributes, the *DUKW No. 1* sank because of a simple human error that occurred during routine maintenance. For a DUKW hull to have watertight integrity, perfect maintenance and operation is essential.

In the case of the *DUKW No. 1*, company procedures required that, before a tour was conducted, both the mechanic and the operator sign the daily maintenance checklist attesting that they had checked 55 items, including engine fluid levels, tires, brakes, driveshaft rubber boots and clamps, and hull plugs. On the day of the accident, however, the operator was in a hurry to pick up waiting passengers and did not take the time to examine all the items listed on the safety checksheet. He told Safety Board investigators that he thought the maintenance access plug had been in place. A review of the daily maintenance checklist for *DUKW No. 1* shows not only that all items were checked, but also that both the operator and the mechanic had attested that the items had been checked. Therefore, a checksheet is no guarantee that necessary maintenance will be performed.

Following the *DUKW No. 1* accident, the owner of the vehicle decided to seal the

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[5] Sinking of the *DUKW No.* 1, Lake Union, Seattle, Washington, December 8, 2001; Brief report in Appendix B of footnote 1.

larger access plugs in all his DUKWs to reduce the likelihood of flooding. The change required some reengineering. Instead of using the forwardmost access plug to access the engine oil sump and filter, the plug was sealed and a portable pump is used to drain the sump. The oil filter was relocated so that it is accessible through the vehicle's hood. Other amphibious passenger vehicle owners should be able to modify their vehicles in a similar manner, thus eliminating a serious risk to passenger safety.

As discussed earlier in this letter, Higgins pumps are subject to multiple failure modes. If a Higgins pump malfunctions and the DUKW vehicle lacks sufficient reserve buoyancy to remain afloat, it could rapidly sink, risking serious injury or death to passengers. Further, the operation of the pump is contingent upon the operation of the engine. The Coast Guard NVIC 1-01 recognizes the need for an independent backup for the Higgins pump sufficient to provide enough dewatering capacity to offset flooding through the largest penetration of the vehicle's hull. In the Safety Board's opinion, dewatering capacity is essential to at least partially compensate for the lack of installed reserve buoyancy. While such capacity is not equivalent to built-in reserve buoyancy sufficient to keep the vehicle afloat in the event of unrestricted flooding, dewatering at least provides some measure of additional protection that may help to keep the vehicle afloat longer, giving passengers more time to escape before the vehicle sinks. Therefore, until such time as reserve buoyancy requirements come into effect for amphibious passenger vehicles, a provision for dewatering capacity should be made mandatory.

Thus, in the Safety Board's opinion, until such time that owners provide sufficient reserve buoyancy in their amphibious passenger vehicles so that they will remain upright and afloat in a fully flooded condition (by M-02-1), regulatory authorities should require equipment and procedural modifications to maximize safety during waterborne operations.

In summary, the National Transportation Safety Board makes the following safety recommendations to the State of Wisconsin:

> Require that amphibious passenger vehicle operators provide reserve buoyancy through passive means, such as watertight compartmentalization, built-in flotation, or equivalent measures, so that the vehicles will remain afloat and upright in the event of flooding, even when carrying a full complement of passengers and crew. (M-02-1).
>
> Until such time that owners provide sufficient reserve buoyancy in their amphibious passenger vehicles so that they will remain upright and afloat in a fully flooded condition (by M-02-1), require the following:
>
> (1) removal of canopies for waterborne operations or installation of a Coast Guard-approved canopy that does not restrict either horizontal or vertical escape by passengers in the event of sinking,
>
> (2) reengineering of each amphibious vehicle to permanently close all unnecessary access plugs and to reduce all necessary through-hull

penetrations to the minimum size necessary for operation,

(3) installation of independently powered electric bilge pumps that are capable of dewatering the craft at the volume of the largest remaining penetration to supplement either an operable Higgins pump or a dewatering pump of equivalent or greater capacity,

(4) installation of four independently powered bilge alarms,

(5) inspection of the vehicle in water after each time a through-hull penetration has been removed or uncovered,

(6) verification of a vehicle's watertight condition in the water at the outset of each waterborne departure, and

(7) compliance with all remaining provisions of *Navigation and Vessel Inspection Circular1-01*. (M-02-2)

Where canopies have been removed on amphibious passenger vehicles for which there is no adequate reserve buoyancy, require that all passengers don lifejackets before the onset of waterborne operations. (M-02-3)

In your response to the recommendations in this letter, please refer to M-02-1 through -3. If you need additional information, you may call (202) 314-6607.

Chairman BLAKEY, Vice Chairman CARMODY and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations.

Original Signed

By: Marion C. Blakey
Chairman

National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: May 24, 2002
In reply refer to: A-02-09 through -11

Honorable Jane F. Garvey
Administrator
Federal Aviation Administration
Washington, D.C. 20591

On July 14, 2001, a Stemme S10-VT powered glider,[1] N502SC, experienced a loss of power in its Rotax 914F2/S1 engine and an in-flight fire after takeoff from Langlade County Airport (AIG), Antigo, Wisconsin.[2] The pilot returned to AIG for an emergency landing. When the airplane touched down on runway 8, the right main landing gear collapsed. The airplane came to rest off the right side of the runway. The airplane was operating on a personal flight under the provisions of 14 *Code of Federal Regulations* (CFR) Part 91. The airplane was destroyed by fire, but the pilot and passenger were not injured.

The pilot reported that approximately 1 mile from AIG, at 1,000 feet above ground level, he heard a loud bang in the engine compartment, which was located directly behind the cockpit. The pilot also reported that the engine immediately began to run rough and that smoke entered the cockpit. The pilot shut down the engine, closed the fuel valve, and lowered the landing gear before the airplane lost all electrical power. The pilot returned to AIG. A witness on the ground stated that while the airplane was on final approach to AIG, a fire was burning through the left side of the fuselage, just aft of the cockpit. The pilot reported that after performing the emergency landing (less than 2 minutes after the initial engine failure) and exiting the airplane, he observed flames burning through the left side of the engine compartment. The pilot further indicated that the ensuing fire engulfed the area forward of the engine compartment within 5 minutes of the initial engine failure.

The Safety Board's examination of the wreckage revealed that the fire originated in the engine compartment and appeared to have started near the left carburetor. The fire destroyed all of the airplane's nonmetallic components (except the outboard portion of the wings) forward of

[1] Federal Aviation Administration (FAA) Advisory Circular (AC) 21.17-2A, "Type Certification—Fixed Wing Gliders (Sailplanes), Including Powered Gliders," indicates that powered gliders are airplanes for which the number of occupants does not exceed two, the maximum weight does not exceed 1,874 pounds (lb), and the maximum weight-to-wing span squared does not exceed 0.62 lb/ft^2. This recommendation letter uses the terms "powered glider" and "airplane" to refer to the Stemme S10-VT.

[2] A description of this accident, CHI01LA216, can be found on the National Transportation Safety Board's Web site at <http://www.ntsb.gov>.

the empennage, including the wing attachment area, which is located directly over the engine compartment. This accident is still under investigation.

Because the accident airplane's engine compartment was destroyed by fire, Safety Board investigators had to examine a new production Stemme S10-VT airplane to determine the configuration of the firewall and the location of the fuel lines. During this examination, Board investigators noted several safety deficiencies in the engine compartment, including unsealed gaps in the firewall, unprotected fuel lines and fittings, and unshielded exhaust components.

Specifically, investigators noted the following: (1) The forward and aft firewalls contain openings as large as 1 inch to accommodate aircraft structural members (tubular steel) and the propeller drive shaft. These openings do not incorporate fireproof grommets, bushings, or firewall fittings, which would prevent a hazardous quantity of liquid, gas, or flame from passing between the engine compartment and other parts of the airplane. (2) Rubber fuel lines and fittings within the engine compartment are not adequately protected with fire-resistant sleeving or with sealed or clamped ends to prevent exposure to engine fires. Further, these unprotected rubber fuel lines and plastic fuel filters are mounted against the forward side of the engine firewall, subjecting them to the radiant heat that would be generated by a fire inside the engine compartment. (3) The carburetors and other associated fuel system components are located directly over unprotected exhaust system components, which under normal operating conditions would be hot enough to ignite flammable fluids or vapors. Further, although the forward, top, and aft sides of the Stemme S10-VT engine compartment are made of 0.040-inch-thick stainless steel sheet metal, the sides and bottom of the engine compartment are made of composite material, which contains hydrocarbons and therefore can easily become fuel for a fire when heated.

The Safety Board notes that, based on the statements of the accident pilot and the witness, the fire spread quickly from the engine compartment to other unprotected areas of the accident airplane after the initial loud bang. The Board considers it likely that safety deficiencies similar to those found in the engine compartment of the new production Stemme S10-VT, noted previously, contributed to the initiation of the fire in the accident airplane and to the speed at which the fire spread. Had the accident airplane been at a higher altitude, the pilot might not have had sufficient time to perform a successful emergency landing. The Board is concerned that the multiple design deficiencies identified in the new production model could pose a serious risk of in-flight fires in the engine compartment of other Stemme S10-VT airplanes. Currently, 38 Stemme S10-VT airplanes are operating in the United States.

The Safety Board notes that the certification criteria applicable to the German-designed and -manufactured Stemme S10-VT include regulatory standards that are intended to prevent these safety deficiencies. Although Stemme submitted statements to the Federal Republic of Germany's aviation certification authority, the Luftfahrt-Bundesamt (LBA), detailing how the Stemme S10-VT airplane complied with those certification criteria, it appears that the Stemme S10-VT design does not in fact comply with those criteria.

Title 14 CFR 21.17(b) indicates that, for the type certification and airworthiness certification of special classes of aircraft (including powered gliders), the applicable

airworthiness criteria provide a level of safety equivalent to Parts 23, 25, 27, 29, 31, 33, and 35. On April 1, 1980, several European civil aviation authorities[3] agreed to the Joint Aviation Requirements (JAR) for Sailplanes and Powered Sailplanes,[4] JAR-22, which is based on the LBA's national airworthiness code. The Stemme S10-VT airplane was certificated by the LBA under JAR-22 on August 15, 1997. In AC 21.17-2A, the FAA indicated that the criteria contained in JAR-22 provided an acceptable level of safety and were therefore appropriate for the type certification of gliders and powered gliders. On September 22, 1997, the FAA Small Airplane Directorate granted FAA Type Certificate No. G06CE for the Stemme S10-VT, with a certification basis of JAR-22. In a March 27, 2002, letter to the FAA's Associate Administrator for Regulation and Certification, the Director of the Safety Board's Office of Aviation Safety questioned the process by which the FAA had certified the Stemme S10-VT and whether, given the design deficiencies in the Stemme S10-VT, the FAA considered the existing certification process to provide an adequate level of safety for foreign-designed and -manufactured products. The letter also requested information about any procedural changes that the FAA has adopted, or plans to adopt, to prevent the type certification of other foreign-manufactured products with design deficiencies.

With regard to sealing the engine compartment, JAR 22.1191 states the following:

> (a) The engine must be isolated from the rest of the sailplane by a firewall, shroud or equivalent means.
> (b) The firewall or shroud must be constructed so that no hazardous quantity of liquid, gas or flame can pass from the engine compartment to other parts of the sailplane.
> (c) The firewall and shroud must be fireproof and protected against corrosion.

Regarding protection of fuel lines and fittings, JAR 22.993(d) states that "[e]ach fuel line and fitting in any area subject to engine fire conditions must be at least fire resistant."[5] With regard to the shielding of exhaust components, JAR 22.1121(b) states the following:

> [e]ach exhaust system part with a surface hot enough to ignite flammable fluids or vapors must be located or shielded so that leakage from any system carrying flammable fluids or vapors will not result in a fire caused by impingement of the fluid or vapors on any part of the exhaust system, including shields for the exhaust system.

The Safety Board notes that the Stemme S10-VT airplane is a derivative of the Stemme S10 and S10-V airplanes. Therefore, in light of the safety deficiencies discussed

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[3] The countries included Belgium, the Federal Republic of Germany, France, Italy, the Netherlands, Sweden, and the United Kingdom.

[4] Although JAR-22 uses the terms "sailplanes" and "powered sailplanes," the terms "gliders" and "powered gliders" are also used to describe these aircraft.

[5] AC 20-135, "Powerplant Installation and Propulsion System Component Fire Protection Test Methods, Standards and Criteria," indicates the following:

> When applied to powerplant installations such as fluid-carrying lines, flammable fluid system components, wiring, air ducts, fittings and powerplant controls, "fire resistant" means the capability of a material or component to perform its intended functions under the heat and other conditions likely to occur at the particular location and to withstand a 2000ºF [Fahrenheit] flame (±150ºF) for 5 minutes minimum.

previously, the Safety Board believes that the FAA should require that existing Stemme S10, S10-V, and S10-VT powered gliders be modified to reduce the risk of fires in the engine compartment, including sealing the engine compartment, protecting fuel lines and fittings, and shielding exhaust components. Further, the Safety Board believes that the FAA should require that future Stemme S10, S10-V, and S10-VT powered gliders be designed and manufactured to reduce the risk of fires in the engine compartment, including sealing the engine compartment, protecting fuel lines and fittings, and shielding exhaust components.

Finally, the Safety Board notes that while these design changes are being developed and implemented, operators of the affected Stemme airplanes could benefit from being made aware of the circumstances of this accident. Therefore, the Safety Board believes that the FAA should notify all registered operators of Stemme S10, S10-V, and S10-VT powered gliders about the circumstances of the July 14, 2001, Antigo, Wisconsin, accident, including their related design deficiencies.

Therefore, the National Transportation Safety Board recommends that the Federal Aviation Administration:

> Require that existing Stemme S10, S10-V, and S10-VT powered gliders be modified to reduce the risk of fires in the engine compartment, including sealing the engine compartment, protecting fuel lines and fittings, and shielding exhaust components. (A-02-09)
>
> Require that future Stemme S10, S10-V, and S10-VT powered gliders be designed and manufactured to reduce the risk of fires in the engine compartment, including sealing the engine compartment, protecting fuel lines and fittings, and shielding exhaust components. (A-02-10)
>
> Notify all registered operators of Stemme S10, S10-V, and S10-VT, powered gliders about the circumstances of the July 14, 2001, Antigo, Wisconsin, accident, including their related design deficiencies. (A-02-11)

Chairman BLAKEY, Vice Chairman CARMODY, and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations.

Original Signed

By: Marion C. Blakey
Chairman

National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: May 24, 2002

In reply refer to: H-02-02 and -03

Honorable Mary E. Peters
Administrator
Federal Highway Administration
400 Seventh Street, S.W.
Washington, D.C. 20590

About 8 a.m. on July 26, 2000, a work zone project began near milepost 85.6 on eastbound Interstate Highway 40 (I-40) in Jackson, Tennessee. This was the third day of an operation that consisted of milling rumble strips into the shoulder pavement. The three construction vehicles that were involved were positioned along the outside shoulder of the interstate. Two Tennessee Highway Patrol (THP) vehicles, with their emergency lights flashing, were also present to assist with enforcement and traffic control. The THP vehicles were stopped 450 feet and 950 feet, respectively, behind the construction vehicles along the right lane.

About 8:52 a.m., an eastbound 1999 International truck tractor pulling a loaded semitrailer, and traveling at a driver-estimated speed of 65 mph in a 55-mph work zone, collided with the trailing THP vehicle. Witnesses reported that the patrol car exploded and caught fire at impact. The patrol car was pushed approximately 192 feet before it came to rest in the median. The tractor-semitrailer continued through a 61-foot depressed earthen median and into the westbound lanes, where it collided with a 1997 Chevrolet Blazer. The tractor-semitrailer then continued across the travel lanes and came to rest in a wooded area on the north side of I-40. The State trooper in the THP vehicle was killed, and the Chevrolet driver was seriously injured.[1]

The National Transportation Safety Board determines that the probable cause of this accident was the driver's incapacitation, owing to the failure of the medical certification process to detect and remove a medically unfit driver from service. Contributing to this accident were the lack of planning and coordination between the Tennessee Department of Transportation, its contractors, and the Tennessee Highway Patrol regarding work zone projects; the lack of traffic control training, specific to highway work zone operations, provided to Tennessee Highway Patrol officers; and the failure of the Tennessee Department of Transportation and its contractors to protect all work zone personnel and road users.

[1] For more information, read: National Transportation Safety Board, *Work Zone Collision Between a Tractor-Semitrailer and a Tennessee Highway Patrol Vehicle, Jackson, Tennessee, July 26, 2000,* Highway Accident Report NTSB/HAR-02/01 (Washington, DC: NTSB, 2001).

Law enforcement personnel are typically trained to perform short-term traffic control functions for specific events. These functions include providing enforcement and traffic control support at accident scenes, at intersections with malfunctioning or missing traffic control devices, in work zones, when escorting permitted (oversize) vehicles, and during special events that generate heavy traffic. However, the Safety Board found that the THP officers lacked the guidance and training necessary to provide safe and effective traffic control for the unique situations found in long-term work zone environments. Work zone operations are not covered in THP General Order 405, which governs traffic direction and control.

As part of its investigation, the Safety Board conducted a limited survey of the police work zone training practices in Maryland, Delaware, Connecticut, and New Jersey. Among those surveyed, only New Jersey had officers who are trained in Part VI of the *Manual on Uniform Traffic Control Devices* (MUTCD) and other traffic control safety standards. New Jersey State Police assigned to the construction unit are authorized to enforce the rules and regulations governing traffic control and safety in highway work areas. The officers may even inspect construction sites to ensure that contractors comply with the traffic control plans established for their projects. According to the supervising engineer of the New Jersey Department of Transportation Office of Capitol Project Safety, having trained officers patrolling New Jersey work zones has resulted in more uniform implementation of traffic control plans, better control of construction projects, and increased safety for workers and the traveling public.

Instruction and training similar to that given to the New Jersey construction unit would have benefited the THP officers assigned to the milling operation in Jackson. Prior to the milling operation, the Dement Construction Company foreman advised the THP officers that the operation would involve a "mobile lane closure." By this, he meant that all of the construction vehicles would be positioned on the shoulder of the highway and that traffic control efforts would be directed toward informing motorists ahead of time of the operation and keeping them away from the shoulder and a safe distance from the milling operation. Although the construction foreman indicated that he did not intend that the THP close the right lane, the phrase "mobile lane closure" could easily be construed to mean "close the lane." "Mobile lane closure" is not a term used in the MUTCD, nor was a mobile operation mentioned in the Jackson traffic control plan. Yet, the THP did not ask for clarification and proceeded to position their vehicles behind the construction vehicles in an unsafe manner. The Safety Board concludes that had the THP officers received work zone traffic control training, they may have asked the construction foreman for clarification on the traffic control strategy to be used that day. The Safety Board further concludes had the THP officers received work zone traffic control training, they would have realized the hazards of positioning their vehicles in the lane behind the highway construction vehicles.

Since the Jackson accident, the THP has worked with the Federal Highway Administration (FHWA) to develop training programs on MUTCD traffic control strategies for its supervisors and officers. The Safety Board supports the efforts of the THP and the FHWA to reduce work zone-related accidents through training. This effort places Tennessee in the forefront on the work zone training issue because, as the FHWA's survey, *Use of Uniformed Police Officers on Federal-Aid Highway Construction Projects*, indicates, three-fourths of responding State agencies do not have a program in place or under development to train police officers on work zone safety standards. New Jersey has adopted such a training program and

believes that it has contributed to the implementation of more uniform traffic control plans and better controlled construction projects and has also led to a significant reduction in work zone-related fatalities.

However, trained officers are of little use if not properly utilized. According to the FHWA's survey, a majority of the States use uniformed police officers in at least some work zones, most often where particular traffic safety concerns exist, such as in work zones with high speed and high traffic volume and in work zones with lane closure or nighttime operations unprotected by a concrete barrier. Part VI of the MUTCD encourages the use of police officers in work zone operations, stating that the "use of police in vulnerable work situations, particularly those of relatively short duration, heightens the awareness of passing traffic and will likely cause a reduction in travel speed."

Although the use of police officers is promoted as a way to increase work zone safety, no specific guidance exists that addresses the need to coordinate traffic control and enforcement activities with the officers. The MUTCD, which codifies the principles and procedures used by all States when designing and implementing work zones, does not provide guidance on this issue. The accident in Jackson illustrates the importance of a coordinated effort in creating a safe work zone environment for workers and the traveling public. The Safety Board concludes that the widespread use of police officers at highway work zones underscores the need for standard guidance to assist construction and maintenance workers in coordinating traffic control, enforcement, and other safety-related tasks with police officers assigned to work zones.

Therefore, the National Transportation Safety Board recommends that the Federal Highway Administration:

> Review and revise the *Manual on Uniform Traffic Control Devices* to provide guidance on coordination with law enforcement personnel used in traffic control strategies at highway work zones. (H-02-02)
>
> In cooperation and consultation with the National Highway Traffic Safety Administration, the International Association of Chiefs of Police, the National Sheriffs' Association, and the American Association of State Highway and Transportation Officials, develop a model training program for law enforcement personnel that addresses traffic control strategies at highway work zones, and encourage the States to adopt it. At a minimum, the training program should incorporate material from Part VI of the *Manual on Uniform Traffic Control Devices* and information concerning procedures and terminology typically used by highway engineers in establishing and evaluating work zone operations. (H-02-03)

The Safety Board also issued safety recommendations to the National Highway Traffic Safety Administration, the Tennessee Department of Transportation, the National Sheriffs' Association, the International Association of Chiefs of Police, and the American Association of State Highway and Transportation Officials.

Please refer to Safety Recommendations H-02-02 and -03 in your reply. If you need additional information, you may call (202) 314-6607.

Chairman BLAKEY, Vice Chairman CARMODY, and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations.

Original Signed

By: Marion C. Blakey
Chairman

National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: May 24, 2002

In reply refer to: H-02-04

Honorable Jeffrey W. Runge
Administrator
National Highway Traffic Safety Administration
400 Seventh Street, S.W.
Washington, D.C. 20590

About 8 a.m. on July 26, 2000, a work zone project began near milepost 85.6 on eastbound Interstate Highway 40 (I-40) in Jackson, Tennessee. This was the third day of an operation that consisted of milling rumble strips into the shoulder pavement. The three construction vehicles that were involved were positioned along the outside shoulder of the interstate. Two Tennessee Highway Patrol (THP) vehicles, with their emergency lights flashing, were also present to assist with enforcement and traffic control. The THP vehicles were stopped 450 feet and 950 feet, respectively, behind the construction vehicles along the right lane.

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As part of its investigation, the Safety Board conducted a limited survey of the police work zone training practices in Maryland, Delaware, Connecticut, and New Jersey. Among those surveyed, only New Jersey had officers who are trained in Part VI of the *Manual on Uniform Traffic Control Devices* (MUTCD) and other traffic control safety standards. New Jersey State Police assigned to the construction unit are authorized to enforce the rules and regulations governing traffic control and safety in highway work areas. The officers may even inspect construction sites to ensure that contractors comply with the traffic control plans established for their projects. According to the supervising engineer of the New Jersey Department of Transportation Office of Capitol Project Safety, having trained officers patrolling New Jersey work zones has resulted in more uniform implementation of traffic control plans, better control of construction projects, and increased safety for workers and the traveling public.

Instruction and training similar to that given to the New Jersey construction unit would have benefited the THP officers assigned to the milling operation in Jackson. Prior to the milling operation, the Dement Construction Company foreman advised the THP officers that the operation would involve a "mobile lane closure." By this, he meant that all of the construction vehicles would be positioned on the shoulder of the highway and that traffic control efforts would be directed toward informing motorists ahead of time of the operation and keeping them away from the shoulder and a safe distance from the milling operation. Although the construction foreman indicated that he did not intend that the THP close the right lane, the phrase "mobile lane closure" could easily be construed to mean "close the lane." "Mobile lane closure" is not a term used in the MUTCD, nor was a mobile operation mentioned in the Jackson traffic control plan. Yet, the THP did not ask for clarification and proceeded to position their vehicles behind the construction vehicles in an unsafe manner. The Safety Board concludes that had the THP officers received work zone traffic control training, they may have asked the construction foreman for clarification on the traffic control strategy to be used that day. The Safety Board further concludes had the THP officers received work zone traffic control training, they would have realized the hazards of positioning their vehicles in the lane behind the highway construction vehicles.

Since the Jackson accident, the THP has worked with the Federal Highway Administration (FHWA) to develop training programs on MUTCD traffic control strategies for its supervisors and officers. The Safety Board supports the efforts of the THP and the FHWA to reduce work zone-related accidents through training. This effort places Tennessee in the forefront on the work zone training issue because, as the FHWA's survey, *Use of Uniformed Police Officers on Federal-Aid Highway Construction Projects*, indicates, three-fourths of responding State agencies do not have a program in place or under development to train police officers on work zone safety standards. New Jersey has adopted such a training program and

believes that it has contributed to the implementation of more uniform traffic control plans and better controlled construction projects and has also led to a significant reduction in work zone-related fatalities.

Therefore, the National Transportation Safety Board recommends that the National Highway Traffic Safety Administration:

> Work with the Federal Highway Administration to develop a model training program for law enforcement personnel that addresses traffic control strategies at highway work zones. At a minimum, the training program should incorporate material from Part VI of the *Manual on Uniform Traffic Control Devices* and information concerning procedures and terminology typically used by highway engineers in establishing and evaluating work zone operations. (H-02-04)

The Safety Board also issued safety recommendations to the Federal Highway Administration, the Tennessee Department of Transportation, the National Sheriffs' Association, the International Association of Chiefs of Police, and the American Association of State Highway and Transportation Officials.

Please refer to Safety Recommendation H-02-04 in your reply. If you need additional information, you may call (202) 314-6607.

Chairman BLAKEY, Vice Chairman CARMODY, and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in this recommendation.

Original Signed

By: Marion C. Blakey
Chairman

National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: May 24, 2002

In reply refer to: H-02-05

Mr. J. Bruce Saltsman, Sr.
Commissioner
Tennessee Department of Transportation
James K. Polk Building
505 Deaderick Street, Suite 700
Nashville, Tennessee 37243

The National Transportation Safety Board is an independent Federal agency charged by Congress with investigating transportation accidents, determining their probable cause, and making recommendations to prevent similar accidents from occurring. We are providing the following information to urge your organization to take action on the safety recommendation in this letter. The Safety Board is vitally interested in this recommendation because it is designed to prevent accidents and save lives.

This recommendation addresses preconstruction conferences for work zone projects. The recommendation is derived from the Safety Board's investigation of the work zone collision between a tractor-semitrailer and a Tennessee Highway Patrol (THP) vehicle in Jackson, Tennessee, on July 26, 2000,[1] and is consistent with the evidence it found and the analysis it performed. As a result of this investigation, the Safety Board has issued five safety recommendations, one of which is addressed to the Tennessee Department of Transportation (TDOT). Information supporting this recommendation is discussed below. The Safety Board would appreciate a response from you within 90 days addressing the actions you have taken or intend to take to implement this recommendation.

About 8:52 a.m. on July 26, 2000, an eastbound 1999 International truck tractor pulling a loaded semitrailer, and traveling at a driver-estimated speed of 65 mph in a 55-mph work zone, collided with the trailing THP vehicle. Witnesses reported that the patrol car exploded and caught fire at impact. The patrol car was pushed approximately 192 feet before it came to rest in the median. The tractor-semitrailer continued through a 61-foot depressed earthen median and into the westbound lanes, where it collided with a 1997 Chevrolet Blazer. The tractor-semitrailer then continued across the travel lanes and came to rest in a wooded area on the north side of Interstate Highway 40. The State trooper in the THP vehicle was killed, and the Chevrolet driver was seriously injured.

[1] For more information, read: National Transportation Safety Board, *Work Zone Collision Between a Tractor-Semitrailer and a Tennessee Highway Patrol Vehicle, Jackson, Tennessee, July 26, 2000,* Highway Accident Report NTSB/HAR-02/01 (Washington, DC: NTSB, 2001).

The National Transportation Safety Board determines that the probable cause of this accident was the driver's incapacitation, owing to the failure of the medical certification process to detect and remove a medically unfit driver from service. Contributing to this accident were the lack of planning and coordination between the Tennessee Department of Transportation, its contractors, and the Tennessee Highway Patrol regarding work zone projects; the lack of traffic control training, specific to highway work zone operations, provided to Tennessee Highway Patrol officers; and the failure of the Tennessee Department of Transportation and its contractors to protect all work zone personnel and road users.

The accident occurred on the third day of an operation that consisted of milling rumble strips into the shoulder pavement. About 8 a.m. on July 26, 2000, two THP officers positioned their vehicles, with their emergency lights flashing, within the right eastbound lane of a high-speed roadway in order to warn motorists away from the milling machine and the sweeper on the roadway shoulder. Although variable message signs warned motorists of the roadwork ahead and of a lane closure, the signs failed to specify which lane was closed. No channeling devices were positioned behind the officers to direct motorists to the left lane. In addition, the protection vehicle towing the flashing arrow board was positioned behind the sweeping machine, 950 feet ahead of the trailing police vehicle.

On the previous day, the vague messages displayed on the variable message signs had prompted motorists to complain to TDOT that they could not tell which lane was closed. The unprotected positions of the THP vehicles had generated sufficient complaints by TDOT personnel to the Regional Safety Coordinator to merit an inspection of the work zone operation. The accident occurred before this inspection could take place.

At the time of the accident, TDOT was employing a traffic control plan that was not covered in the construction contract. In fact, the contract did not contain a traffic control plan that was applicable to mobile operations such as milling rumble strips or performing pavement striping and other lane marking operations. Furthermore, the contract did not specify the THP's duties with regard to traffic control within the work zone.

The failure to define a specific traffic control plan for the milling operation suggests that too little planning had been devoted to that operation, which may have led to the ambiguous information displayed on variable message signs and to other questionable safety practices discussed below. The lack of a specific traffic control plan, in conjunction with the absence of the THP in the preconstruction conferences, quite likely added to the contractor's uncertainty with regard to the THP's role in the milling project. These circumstances may have fostered the misconception that the THP officers did not need additional guidance on work zone operations. The Safety Board concludes that the traffic control and safety aspects of the work zone operation would have been improved had the construction contract incorporated traffic control plans for all aspects of the work zone operation and assigned specific responsibilities to each party.

The Construction Accident Reduction Project (Project CAR) is a mechanism for TDOT to contract with the THP to provide enforcement and traffic control assistance on this construction project. Despite the THP's role in the project, it was not invited to attend the TDOT preconstruction conference meetings. Typically, participants in a preconstruction conference discuss the scope of a construction project; the time, resources, and procedures needed to

complete it; and the traffic control plan that best suits each phase of the project. Large projects, such as the one in Jackson, usually involve the State's Department of Transportation and several contractors and subcontractors. Because of the number of parties involved, communication and coordination are vital in establishing a work zone strategy that is both effective and safe.

Not seeking THP representation resulted in a lost opportunity for Dement Construction Company and THP representatives to coordinate traffic control duties. It also meant that TDOT could not clarify to all involved who was in charge of traffic control in the work zone. This clarification would have been helpful, given the natural assumption that police officers are in charge of traffic control. The end result was a disjointed traffic control effort between the TDOT contractor and the THP that was inherently unsafe. The Safety Board concludes that had TDOT invited the THP to the preconstruction conferences, lines of communication may have been established, enabling the parties to agree upon traffic control responsibilities and clarify the manner in which they should be performed.

Therefore, the National Transportation Safety Board recommends that the Tennessee Department of Transportation:

> Conduct preconstruction conferences with all parties involved in a work zone project. As a result of such conferences, produce a written traffic control plan or project plan agreed to by all parties that defines the lines of authority and how traffic control and enforcement will be performed for all types of work zone configurations to be utilized. (H-02-05)

The Safety Board also issued safety recommendations to the Federal Highway Administration, the National Highway Traffic Safety Administration, the National Sheriffs' Association, the International Association of Chiefs of Police, and the American Association of State Highway and Transportation Officials. In your response to the recommendation in this letter, please refer to H-02-05. If you need additional information, you may call (202) 314-6607.

Chairman BLAKEY, Vice Chairman CARMODY, and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in this recommendation.

Original Signed

By: Marion C. Blakey
Chairman

National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: May 24, 2002

In reply refer to: H-02-06

Mr. Thomas N. Faust
Executive Director
National Sheriffs' Association
1450 Duke Street
Alexandria, Virginia 22314-3490

Mr. John Horsley
Executive Director
American Association of State
Highway and Transportation Officials
444 North Capitol Street, Suite 249
Washington, D.C. 20001

Mr. William B. Berger
President
International Association of Chiefs of Police
515 North Washington Street
Alexandria, Virginia 22314

The National Transportation Safety Board is an independent Federal agency charged by Congress with investigating transportation accidents, determining their probable cause, and making recommendations to prevent similar accidents from occurring. We are providing the following information to urge your organization to take action on the safety recommendation in this letter. The Safety Board is vitally interested in this recommendation because it is designed to prevent accidents and save lives.

This recommendation addresses training law enforcement personnel about safe traffic control procedures within highway work zones. The recommendation is derived from the Safety Board's investigation of the work zone collision between a tractor-semitrailer and a Tennessee Highway Patrol (THP) vehicle in Jackson, Tennessee, on July 26, 2000,[1] and is consistent with the evidence it found and the analysis it performed. As a result of this investigation, the Safety Board has issued five safety recommendations, one of which is addressed to the National Sheriffs' Association, the International Association of Chiefs of Police, and the American Association of State Highway and Transportation Officials. Information supporting this recommendation is discussed below. The Safety Board would appreciate a response from you within 90 days addressing the actions you have taken or intend to take to implement this recommendation.

About 8 a.m. on July 26, 2000, a work zone project began near milepost 85.6 on eastbound Interstate Highway 40 (I-40) in Jackson, Tennessee. This was the third day of an

[1] For more information, read: National Transportation Safety Board, *Work Zone Collision Between a Tractor-Semitrailer and a Tennessee Highway Patrol Vehicle, Jackson, Tennessee, July 26, 2000,* Highway Accident Report NTSB/HAR-02/01 (Washington, DC: NTSB, 2001).

operation that consisted of milling rumble strips into the shoulder pavement. The three construction vehicles that were involved were positioned along the outside shoulder of the interstate. Two THP vehicles, with their emergency lights flashing, were also present to assist with enforcement and traffic control. The THP vehicles were stopped 450 feet and 950 feet, respectively, behind the construction vehicles along the right lane.

About 8:52 a.m., an eastbound 1999 International truck tractor pulling a loaded semitrailer, and traveling at a driver-estimated speed of 65 mph in a 55-mph work zone, collided with the trailing THP vehicle. Witnesses reported that the patrol car exploded and caught fire at impact. The patrol car was pushed approximately 192 feet before it came to rest in the median. The tractor-semitrailer continued through a 61-foot depressed earthen median and into the westbound lanes, where it collided with a 1997 Chevrolet Blazer. The tractor-semitrailer then continued across the travel lanes and came to rest in a wooded area on the north side of I-40. The State trooper in the THP vehicle was killed, and the Chevrolet driver was seriously injured.

The National Transportation Safety Board determines that the probable cause of this accident was the driver's incapacitation, owing to the failure of the medical certification process to detect and remove a medically unfit driver from service. Contributing to this accident were the lack of planning and coordination between the Tennessee Department of Transportation, its contractors, and the Tennessee Highway Patrol regarding work zone projects; the lack of traffic control training, specific to highway work zone operations, provided to Tennessee Highway Patrol officers; and the failure of the Tennessee Department of Transportation and its contractors to protect all work zone personnel and road users.

Law enforcement personnel are typically trained to perform short-term traffic control functions for specific events. These functions include providing enforcement and traffic control support at accident scenes, at intersections with malfunctioning or missing traffic control devices, in work zones, when escorting permitted (oversize) vehicles, and during special events that generate heavy traffic. However, the Safety Board found that the THP officers lacked the guidance and training necessary to provide safe and effective traffic control for the unique situations found in long-term work zone environments. Work zone operations are not covered in THP General Order 405, which governs traffic direction and control.

As part of its investigation, the Safety Board conducted a limited survey of the police work zone training practices in Maryland, Delaware, Connecticut, and New Jersey. Among those surveyed, only New Jersey had officers who are trained in Part VI of the *Manual on Uniform Traffic Control Devices* (MUTCD) and other traffic control safety standards. New Jersey State Police assigned to the construction unit are authorized to enforce the rules and regulations governing traffic control and safety in highway work areas. The officers may even inspect construction sites to ensure that contractors comply with the traffic control plans established for their projects. According to the supervising engineer of the New Jersey Department of Transportation Office of Capitol Project Safety, having trained officers patrolling New Jersey work zones has resulted in more uniform implementation of traffic control plans, better control of construction projects, and increased safety for workers and the traveling public.

Instruction and training similar to that given to the New Jersey construction unit would have benefited the THP officers assigned to the milling operation in Jackson. Prior to the milling

operation, the Dement Construction Company foreman advised the THP officers that the operation would involve a "mobile lane closure." By this, he meant that all of the construction vehicles would be positioned on the shoulder of the highway and that traffic control efforts would be directed toward informing motorists ahead of time of the operation and keeping them away from the shoulder and a safe distance from the milling operation. Although the construction foreman indicated that he did not intend that the THP close the right lane, the phrase "mobile lane closure" could easily be construed to mean "close the lane." "Mobile lane closure" is not a term used in the MUTCD, nor was a mobile operation mentioned in the Jackson traffic control plan. Yet, the THP did not ask for clarification and proceeded to position their vehicles behind the construction vehicles in an unsafe manner. The Safety Board concludes that had the THP officers received work zone traffic control training, they may have asked the construction foreman for clarification on the traffic control strategy to be used that day. The Safety Board further concludes that had the THP officers received work zone traffic control training, they would have realized the hazards of positioning their vehicles in the lane behind the highway construction vehicles.

Since the Jackson accident, the THP has worked with the Federal Highway Administration (FHWA) to develop training programs on MUTCD traffic control strategies for its supervisors and officers. The Safety Board supports the efforts of the THP and the FHWA to reduce work zone-related accidents through training. This effort places Tennessee in the forefront on the work zone training issue because, as the FHWA's survey on the use of uniformed police officers indicates, three-fourths of responding State agencies do not have a program in place or under development to train police officers on work zone safety standards. New Jersey has adopted such a training program and believes that it has contributed to the implementation of more uniform traffic control plans and better controlled construction projects and has also led to a significant reduction in work zone-related fatalities.

Therefore, the National Transportation Safety Board recommends that the National Sheriffs' Association, the International Association of Chiefs of Police, and the American Association of State Highway and Transportation Officials:

> Work with the Federal Highway Administration to develop a model training program for law enforcement personnel that addresses highway work zone safety. At a minimum, the training program should incorporate material from Part VI of the *Manual on Uniform Traffic Control Devices* and information concerning procedures and terminology typically used by highway engineers in establishing and evaluating work zone operations. (H-02-06)

The Safety Board also issued safety recommendations to the Federal Highway Administration, the National Highway Traffic Safety Administration, and the Tennessee Department of Transportation. In your response to the recommendation in this letter, please refer to H-02-06. If you need additional information, you may call (202) 314-6607.

Chairman BLAKEY, Vice Chairman CARMODY, and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in this recommendation.

Original Signed

By: Marion C. Blakey
Chairman